US Army Corps of Engineers

Hydrologic Engineering Center

Third Quarter Activity Report

FY 1999

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Activity Report

Hydrologic Engineering Center **Third Quarter 1999**

Executive Summary

Activity this quarter was most intense on WCDS Test 1.0 installation, readying/releasing new products under the NexGen project, closing out and starting major technical assistance and R&D projects, and continuing efforts in the upper Mississippi Basin flood frequency study and Mississippi Basin Modeling System activities. Reimbursable projects continue to flow in, and model maintenance subscription fees continued to come in slowly, but are nearing completion.

The Water Control Data System (WCDS) software modernization and integration project is now in the third year of an intensive five and one half year development and deployment effort. WCDS is the Corps decision support Automated Information Systems (AIS) that serves the Corps water management mission. Activity this past quarter focused on Test 1.0 installation. This is the first of two planned interim test installation prior to Test 3.0/WCDS Version 1.0, which will complete the system that will be deployed Corps-wide in 2001/2002. In the 2nd quarter, installation had taken place in Baltimore and Huntington Districts. This past quarter, installations were completed at the two remaining sites: Omaha District and Northwest Region - Portland. HEC teams installed the data acquisition and data management software followed by installation and training in decision support modeling and use. Activities continued throughout the third quarter focusing on resolving problems that arose during installation, solidifying the Test 1.0 software system, and holding post-installation evaluation and Corps Users Review Group (CURG)/ System Design and Test (SDT) team meetings. Material about these meetings are posted on the Web at: http://cw71.cw-wc.usace.army.mil/cwcinfo/cwc.html. A meeting of the senior management level Advisory Group is planned for July.

The NexGen software research and development project continues to roll along. The companion HEC-RAS Arc/Info GIS applications package (HEC-GeoRAS) that will provide cross section geometry from digital terrain models, and enable automated inundation mapping was released. It is being applied in a major project that will provide the basis for an illustrated applications guide. An ArcView version of HEC-GeoRAS is now being tested. The next major release of HEC-RAS, late in the calendar year, will likely include both these companion GIS applications packages. A similar GIS companion to HEC-HMS, coined GeoHMS is in a preliminary beta stage and has a planned release of next Fiscal Year. Good progress continues for the planned summer release of Version 2.0 of HEC-HMS. This release will include a continuous moisture accounting loss algorithm, as well as other additions. Progress continues on the two NexGen software programs that are components of the WCDS. The real-time reservoir operations model (HEC-RSS), and a flood impact analysis model (HEC-FIA) are both components of the Test 1.0 WCDS software installation discussed above. The HEC-FIA program is being applied in the Sacramento-San Joaquin Comprehensive Study. These programs will continue to be improved and will eventually be released in stand-alone form. The HEC-FIA is further along and will be released next year.

The re-study of flood frequency on the upper Mississippi River in light of the flood of 1993 is entering the final phase. A report documenting the flow-frequency analysis results is due out in September 1999. Activities this past quarter included briefing stakeholders on methodology and data compilation efforts, and continuing with detailed analysis.

The project to update the model geometry for the Mississippi Basin Model System (MBMS) for the upper Mississippi to reflect more recent mapping and to develop an inundation mapping component based on the new mapping continues in full production mode. This effort will merge the several mapping sources into a digital DTM, cut spatially located cross sections from the DTM, and integrate the new data into re-calibrated UNET unsteady flow models. Automated

inundation area mapping based on UNET forecasts will be made operational for selected areas. Contracts to merge the data sources and cut the cross sections have now all been awarded. New digital cross section data will start flowing to the districts in the fourth quarter and be completed in the second quarter of FY 2000. A workshop was held that focused on tools and techniques for integration of the new digital geometry into the existing UNET models, and techniques for re-calibration of the models. The MBMS update is expected to be completed in mid- FY 2000.

We completed the major reimbursable project to assist in modeling the Sacramento and San Joaquin river basins for flood control operations. Models were completed for the Sacramento Valley and San Joaquin Valley of: HEC-5 for flood control operations; HEC-FCLP, system flood control operation optimization; and HEC-FIA, flood economic/damage impact analysis model. These models were made operational for the recent 1995 and 1997 large flood events. We initiated Phase II of the project, which consists of detailed data compilation and development of gridded HEC-HMS models for contributing watersheds to the San Joaquin and Sacramento Valleys.

We completed participation in the pilot effort involving risk-based analysis of the safety of Alamo Dam in southern Arizona. Activities began on the new dam safety R&D program. HEC is investigating Hydrologic Loading Uncertainty and Estimating Probability of Extreme Floods. These activities reflect a growing national/international interest in applying appropriate risk-based analysis methods to dam safety issues.

Darryl W. Davis, P.E.
Director

HYDROLOGIC ENGINEERING RESEARCH PROGRAM

Catchment Analysis System
Work Unit 32444 (research 3rd/99 R99-001)

Version 1.1 has been well received by users - it's now quite stable after many of the initial program bugs were fixed. The HEC-HMS Technical Reference Manual was completed and is ready for a draft release. The technical reference manual will be updated per draft-release comments and will include new soil moisture accounting capabilities which will be issued with Version 2.0 later this year. The snow preprocessor is still undergoing applications testing at CRREL and should be available for HEC applications next quarter.

Our original intent to recompile and link Version 1.1 with updated releases of the Galaxy software development system as well as several of the support libraries had to be abandoned. Galaxy has not sufficiently developed the new software for our use yet. We will continue with the existing libraries for Version 2.0. Version 2.0 of HEC-HMS has detailed soil moisture accounting capabilities; the computational engines are complete and the GUI codes are designed and being built. The Java testing for graphics and GUI use in HEC-HMS was successful; we will begin converting part of HEC-HMS to Java next quarter.

River Analysis System
Work Unit 32443 (training 3rd/99 R99-002)

This work unit will produce a uniform set of tools for use by hydraulic engineers in a workstation environment. The River Analysis System (HEC-RAS), Version 1.0 program was completed, the Hydraulic Reference and User's manuals were published, and the package started distribution in August 1995. The program is a Windows-based standard-step model that computes steady-flow profiles for subcritical, supercritical, or mixed flow regimes. During FY 1996, Version 1.1 and 1.2 were released to provide error corrections and an added program capability. In FY 1997, in-line weirs and spillways, channel modifications, links to 3D geometric data, and numerous program enhancements were completed. The Federal Highway bridge model and scour analysis were added with FHWA funding, and Version 2.0, plus three reference documents were distributed. In FY 1998, the components of an unsteady flow program were completed for processing cross sections, bridges, and culverts. Also, steady-flow Versions 2.1 and 2.2 were developed. During the first quarter of FY 1999, HEC-RAS Version 2.2 and new program documentation were completed and distributed. Development of the unsteady-flow capability continues. A beta version for testing is expected this FY.

Resolving Water Allocation and Use Conflicts
Work Unit 32976 (planning 3rd/99 R99-003)

This R&D work unit features development and application of reservoir system optimization programs to assist in resolving water allocation and use conflicts that arise from changing conditions. The two primary programs are the Prescriptive Reservoir Model (HEC-PRM) and Flood Control Linear Program (HEC-FCLP). The research continues to push the state-of-the-art in operations research modeling for flood analysis by enabling more detailed representation of the system. Research during the third quarter focused on implementing: an enhanced solver; formulation of a better solution matrix; capability of limiting the foresight to mimic operation capabilities; and testing of commercial "data mining" software to assist with interpretation of the output.

Statistical Methods in Hydrology
Work Unit 32599 (research 3rd/99 R99-004)

Most of the statistics work has concentrated on analysis of large river flow-frequency distributions in conjunction with the upper Mississippi system study. A detailed review of the Corps Hydrologic Frequency Analysis guidance, EM 1110-2-1415 was made. Work on making the HEC statistics library (statLib) a part of the new HEC-DSS was still delayed pending completion of the new DSS package. HEC continues to chair the Interagency Work Group on Flood Frequency analysis and enlist their assistance with review of the Upper Mississippi River System flood frequency study.

Reservoir Analysis System
Work Unit 32602 (training 3rd/99 R99-005)

The objective of this work unit is to develop a family of reservoir analysis tools to facilitate a broad range of investigations ranging from reconnaissance-level planning studies to detailed reservoir regulation plan investigations. These tools will complement the existing HEC-5 Simulation of Flood Control and Conservation Systems Program and the Prescriptive Reservoir Model, HEC-PRM. A requirements document for a new reservoir model was completed in FY 1995. During FY 1996, a basic reservoir GUI was developed to create model data and run computer programs HEC-5 and HEC-PRM. In FY 1997, the focus shifted to develop a prototype reservoir model for the water control data system (WCDS). A software design was developed to support the WCDS goals and to provide a next generation system model. During FY 1998, a prototype reservoir model was essentially completed. During the first quarter of FY 1999, the prototype program was completed and demonstrated for the WCDS. Version 1.0 of the program was completed during the third quarter. Program testing will continue during the fourth quarter and draft documentation will be prepared.

Terrain-Based H&H Modeling
Work Unit 32975 (research 3rd/99 R99-007B)

Hydrology. The Cooperative Research and Development Agreement, CRADA, with the Environmental Systems Research Institute, ESRI, and contracts with the University of Texas' Center for Research in Water Resources, CRWR, are working well - good progress is being made on the development of GIS terrain analysis tools, called HEC-GeoHMS, to support HEC-HMS. Technical papers have been written and the basic code developed. HEC is now working on the user documentation. The beta release will be made next quarter. The work has two main components: 1) delineation of watersheds and channels to facilitate the topological description of the river basin for HEC-HMS; and 2) estimation of HEC-HMS watershed parameters as well as general watershed/river characteristics pertinent to hydrologic modeling.

Terrain-Based H&H Modeling
Work Unit 32975 (training 3rd/99 R99-007A)

Hydraulics. With the development of HEC-GeoRAS, the Hydrologic Engineering Center has linked ARC/INFO data development and display capabilities to HEC-RAS for performing hydraulic analysis. HEC-GeoRAS facilitates model development by allowing a hydraulic engineer with little GIS training to develop geometric data for import in HEC-RAS and view exported water surface profile results. HEC-GeoRAS Version 1.0 was released during the third quarter FY 1999, including User's Manual documentation. Future versions of GeoRAS will include the capability to extract land use data for estimation of roughness coefficients for import into, and visual display of velocities exported from HEC-RAS.

Urban Hydrology Methods
Work Unit 32875 (research 3rd/99 R99-008A)

Hydrology. Testing and comparison of detention storage/outlet structures rating curves generated by HEC-1, HEC-RAS, and direct solution of the equations by Excel have been completed. The analysis was performed for different sizes of pipes, depths, and spillways. The next step is to route a hydrograph to these structures by incorporating the storage-outflow relationship in HEC-HMS. The analysis is being performed prior to investigating better ways to perform hydrologic routings through hydraulic structures with inlet, outlet, and backwater control conditions.

Urban Hydrology Methods
Work Unit 32875 (training 3rd/99 R99-008B)

Hydraulics. This work unit will develop modeling features required for many urban studies. The requirements for unsteady flow applications in the urban environment have been reviewed and defined in conjunction with the review of a UNET application for the Sacramento District. Some required hydraulic features will be incorporated with the development of unsteady flow capability in HEC-RAS. During the third quarter of FY 1999, plans were developed to use the hydraulics library, developed for HEC-RAS, to develop hydraulic ratings for water control structures.

Flood Damage Analysis
Work Unit 32876 (planning 3rd/99 R99-009)

This work unit develops software for more efficient flood damage computations. The research efforts are coordinated closely with the Risk Analysis Work Unit 32896 and Geographic Information System Work Unit 33173, Flood Damage Analysis Using GIS Technology. The initial public release Version 1.0 of the new HEC-FDA program and accompanying user's manual was made in January 1998. An updated version, Version 1.1, that fixes several minor computation bugs will be released during the fourth quarter. The conversion of the Version 1.0 Galaxy user interface to Java continued during the quarter. It will be part of the Version 2.0 upgrade scheduled for release in the fall of 1999. Design of a highly integrated impact analysis package including, FDA, FIA, and the GIS flood damage work was initiated during the quarter.

Internet for Planning
Work Unit 33050 (planning 3rd/99 R99-010)

This limited funded work unit targets ways to use the Internet in planning studies. The focus this year is on its use in study management. The test application is the Tres Rios wetlands restoration study where HEC provided technical assistance in water balance analysis and used the Internet as a ways of conveying study information and results to others. This work unit will be completed in FY 1999 with the intent on the use of the Internet becoming a normal process within the framework of the study. No work was performed for this work unit during the third quarter.

Analysis of Ground-Surface Water Interaction
Work Unit 32703 (research 3rd/99 R99-022)

Work continued through coordination with our co-developer in the USGS and his research at the University of Nevada, Reno. The connection of the USGS MODFLOW model to HEC-HMS is proceeding well and an applications-test data set is being prepared.

Development of an Initial Data Warehouse for Coralville Reservoir Water Balance Analysis
Work Unit 33104 (research 3rd/99 R99-023)

Work continued at the University of Iowa; the basic data set has been enlarged and updated on the university computer. An interim report for the data warehouse at the Corps Coralville was prepared for the Comprehensive Flood Impact Response Modeling System (CFIRMS). It was decided that the data warehouse, because of its size, will be housed at the university.

RISK ASSESSMENT RESEARCH PROGRAM

Risk-based Analysis for Flood Damage Reduction Studies Computer Program
Work Unit 32896 (planning 3rd/99 R99-030A)

Development efforts during the third quarter concentrated on adding cost and uncertainty relationships and expanded rating function capabilities for conditions such as debris, bulking, and ice to the HEC-FDA Version 2.0 program scheduled for release during the fall of 1999. Version 1.0 was released in FY 1998. HEC-FDA includes risk-based analysis methods for formulating and evaluating flood damage reduction measures. The work performed is coordinated closely with Hydrologic Engineering Work Unit 32876, Flood Damage Analysis. HEC-FDA operates in Windows 95, 98 and NT, and Sun Solaris UNIX-based operating systems. The package includes a modern GUI, enhanced project damage and performance calculations, and graphical outputs. Uncertainty algorithms for exceedance probability, stage, and damage are an integral part of the program. The program output is consistent with present Corps guidance of ER 1105-2-101, Risk-based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies and EM 1110-2-1619, Risk-based Analysis for Flood Damage Reduction Studies.

Hydrologic Risk & Uncertainty & Environmental Restoration Performance
Work Unit 33214 (planning 3rd/99 R99-031)

Riverine environmental restoration studies require the statistical uncertainty of low- and high- flow regimes affecting the design, maintenance and operation of the project over its life be quantified and included in the analysis. This new work unit will develop, document and deploy risk-based analysis procedures for hydrologic engineering analysis associated with riverine environmental restoration studies. Emphasis is on defining and developing uncertainty methods for hydrologic variables critical to riverine restoration investigations. The work unit represents the hydrologic/hydraulic analytical component of wetlands studies. It is part of a coordinated effort with the Environmental Lab (CEERD-EV) and the Institute for Water Resources (CEWRC-IWR) who are responsible for the biological and policy aspects of the R & D effort. HEC's work during the third quarter was concentrated on developing a draft of a Hydrologic/Hydraulics Guide Manual for Riverine Restoration Studies. A joint seminar among the three offices on riverine restoration studies is being planned for this fall.

Incorporating Cost Uncertainty into HEC-FDA
Work Unit 33158 (planning 3rd/99 R99-032)

HEC is working with the Institute for Water Resources (CEWRC-IWR) on implementing cost and uncertainty analysis into the HEC-Flood Damage Analysis (HEC-FDA) Version 2.0 program. The cost and existing program damage reduced analyses with uncertainty will enable net benefit analysis with uncertainty to be computed in the program. The design for implementation was worked on during the third quarter. CEWRC-IWR is funding the work from a separate work unit of the Risk R&D program.

GEOGRAPHIC INFORMATION SYSTEM RESEARCH PROGRAM

Flood Damage Analysis Using GIS Technology
Work Unit 33173 (planning 3rd/99 R99-040)

This new work unit creates capabilities to perform flood damage assessments in a more integrated manner, reduce field survey time and effort, and provide easy to understand output and displays. The objective is to develop a new Structure Inventory and Analysis capability that is fully integrated with the HEC-FIA and HEC-FDA program to form the HEC Flood Damage Analysis Package. GIS capabilities for structure inventories, flood impact analysis and displays are the integral part of the program. The software will be integrated into the Flood Damage Analysis Package and coordinated with flood impact analysis software and procedures being developed under real-time water control activities. During the third quarter, the research effort continued on development of: 1) alternative GIS methods for structure inventories; 2) computations by grid cells; 3) computations using aerial photograph images, digital elevations, and flood inundations; and 4) spatial output displays. A prototype of the structure inventory tied to the HEC-FDA database and damage calculations for a single event were completed.

Integration of Models and Spatial Technologies
Work unit 33175 (research 3rd/99 R99-041)

The HEC models (HMS, RAS, FDA, FFA, HEC-5/5Q, and the WCDS) descriptions previously input to the catalog of Corps capabilities were updated. Another part of HEC's responsibility in this multi-Lab work unit was to provide a case study of connecting engineering software to commercial, off-the-shelf GIS systems. The HEC-GeoRAS ARCINFO pre- and post-processor for HEC-RAS was successfully demonstrated for that case study and is now being documented. As part of the hydrologic/hydraulic case study modeling effort, HEC will continue its work with the University of Texas and the Environmental Systems Research Institute to enhance GIS applications for HEC's HMS and RAS models. One of the current questions is how to best store gridded data in HEC-DSS and access it from the applications models; a work group has been organized to address this problem.

Risk Analysis for Dam Safety Research Program

Planning Hydrologic-and-Hydraulic Dam-Safety Risk Analysis
Work Unit 33248 (research 3rd/99 R99-050)

The Risk Analysis for Dam Safety Research Program began in mid year after savings and slippage funds were received by Corps HQ. This work unit serves to investigate field needs and prepare the initial work unit documentation. Several meeting were held with researchers in the profession and Corps field offices in preparation for the program review on 9-10 June 1999.

Assessing Hydrologic Loading Uncertainty
Work Unit 33257 (research 3rd/99 R99-051)

The objective of this work unit is to evaluate the current state-of-the-art for estimating uncertainty of extreme floods. The evaluation will consider both the methods of estimation as well as how the resulting values are being applied. Recent work by the National Research Council, and dam owners and dam safety regulatory agencies, both nationally and internationally, will be evaluated. A methodology for estimation of uncertainty in floods ranging from historical floods to probable maximum floods will be developed. That methodology will include an analysis framework that quantifies the uncertainty in hydrologic variables and a numerical approach for integrating these variables to derive the uncertainty in the extreme floods.

Estimating Probability of Extreme Floods
Work Unit 33258 (research 3rd/99 R99-052)

The objective of this work unit is to evaluate the current state-of-the-art for estimating the probability of extreme floods. The evaluation will consider both the methods of estimation as well as how the resulting probabilities are being applied. Recent work by the National Research Council, and dam owners and dam safety regulatory agencies, both nationally and internationally, will be evaluated. Paleoflood, maximum-envelope-flood methods, and other techniques for estimation of the magnitude and probability of extreme floods will be evaluated. A methodology for estimation of flood probabilities ranging from historical floods to probable maximum floods will be developed.

WATER CONTROL DATA SYSTEM MODERNIZATION

The significant tasks for FY 1999 are to install the WCDS Test 1.0 system software in selected field offices, and continue development toward the final version two years hence. Activity this past quarter focused on Test 1.0 installation. This is the first of two planned interim test installations prior to Test 3.0/WCDS Version 1.0, which will complete the system that will be deployed Corps-wide in 2001/2002. In the 2nd quarter, installation had taken place in Baltimore and Huntington Districts. This past quarter, installations were completed at the two remaining sites: Omaha District and Northwest Region - Portland. HEC teams installed the data acquisition and data management software followed by installation and training in decision support modeling and use. Activities that continued throughout the third quarter focused on resolving problems that arose during installation, solidifying the Test 1.0 software system, and holding post-deployment evaluation and Corps Users Review Group (CURG)/ System Design and Test (SDT) team meetings. Material about these meetings are posted on the Web at: (http://cw71.cw-wc.usace.army.mil/cwcinfo/cwc.html). A meeting of the senior management level Advisory Group is planned for July. (executive 3rd/99)

Data Capture

(tech asst 3rd/99 AEM W99-050)

Work continued on fixing problems discovered in the deployment of Version 1.0 and Version 2.0 requirements of the data capture software. The data capture software allows a GOES or AFOS data stream to be fed into the Water Control Data System where it is decoded and posted to the Oracle database. Version 1.0 deployment of the software was completed at the last two sites in the third quarter.

Data Decoding, Transformation and Validation

(tech asst 3rd/99 AEM W99-051)

Work continued in the third quarter on the inclusion of real-time mathematical and table lookup transformation of data as it is received and posted to the Oracle database, the processing of time series data in blocks, and Version 2.0 components.

Data Base System

(tech asst 3rd/99 DJB W99-052)

Deployment site visits for the data base subsystem for Version 1.0 began in March and finished on 7 May. In the weeks following deployment site visits, the developers responded to requests for solutions to problems encountered by field site personnel. Initially, data extracts from Oracle to DSS working files for modeling and transformation/verification were unacceptably slow. A change of the primary key and associated scripts and data base interface software provided a significant improvement in data retrieval performance. This change of the data base data model was implemented after the Huntington site visit. Therefore, the change was implemented remotely at Baltimore and Huntington, with Omaha and Portland receiving it as an initial installation in their site visits. Successive versions of the Data Base Interface (DBI) server provided more tuning of extract/post processing. Later versions of the DBI are able to handle processing of multiple requests for data processing through RMI threads simultaneously. Likewise these later DBI versions are able to process multiple Oracle sessions simultaneously through Java Data Base Connection (JDBC) protocol in multiple TCP/IP threads. The rate of throughput is increased significantly. Feedback from deployment offices and CURG/SDT Team members at tandem meetings in June indicated that data capture and data base systems must be improved to provide a peak rate of 3500 values per minute as stored to the data base. This is now the target for completion of Version 1.0 before development proceeds on Version 2.0.

Data Dissemination

(tech asst 3rd/99 CWF W99-053)

Data Dissemination work for the third Quarter of FY1999 consisted primarily of deployment activities associated with fielding of the Water Control Data System (WCDS) software at four Corps locations. The locations included 3 Districts and 1 Division office. The sites were

Baltimore (NAB), Huntington (LRH), Omaha (NWO), and Portland (NWD). At each of the deployment locations, an Apache Web server was installed along with an example set of Web pages. The intention was to "wire-up" several example Web pages using data from local watersheds and projects during the deployment period. The sample set of Web pages provide practical examples of how to access and display data from the Oracle database. They include display of data as plots, tables, gif images and PDF files. Due to the short implementation time and difficulties encountered with the data acquisition component of the deployment, only a "Data Acquisition Status" Web page and a "Current Conditions" Web page installation were undertaken.

In June of 1999, the Data Dissemination Software Development Team was re-assembled at HEC during a general meeting of the WCDS CURG group. At the meeting, Data Dissemination Project Requirements were re-visited and modified based on field discussion and review. The primary changes for the Data Dissemination group was to add a Web page which could retrieve data from Oracle in a variety of formats including text, SHEF, DSS, and other similar formats.

Data Archiving

(tech asst 3rd/99 DJB W99-054)

Archiving is required to provide data for mission performance accountability, to enable Corps offices to disseminate and/or exchange data, and to provide a consistent data file system suitable as legal documentation. Automated means will be provided for periodic archiving and as needed purging of information from the WCDS data base. Means will also be provided for automated retrieval from the data archive and placement into the WCDS data base or standard dissemination files. Data Archiving was included in the requirements and software design process being overseen by the Data Base SDT Team. Data archiving, was not included in the WCDS Version 1.0 software suite. Significant work on this issue is planned for later in this year.

Flow Forecasting and Forecast Evaluation

(research 3rd/99 W99-055)

Further updates and improvements were made to the GageInterp software for the version 1.0 WCDS testing/deployment. Applications assistance was also provided for use of the new Meteorological Forecast Processor (MFP) and the Hydrologic Forecast Processor (HFP) in the deployment.

Reservoir System Simulation

(training 3rd/99 W99-056)

Starting in FY 1997, requirements for real-time reservoir simulation were completed, a planning budget was developed, and priorities were set to fit the initial budget. Then a conceptual design document was developed to define program operation and a prototype plan was developed for initial program development. During FY 1998, the prototype reservoir program and pilot project data were completed. During the second quarter of FY 1999, deployment started with the Baltimore and Huntington Districts, and deployment in the remaining two offices was completed during the third quarter. Model testing continues with those offices. Version 1.0 modifications were completed during the third quarter and program testing is underway.

River Hydraulics and Stage Forecasting

(training 3rd/99 W99-057)

This element started in FY 1997. During the first half year, program requirements for river-stage forecasting were developed, reviewed, and completed; and a planning budget was developed. During the second half, a conceptual design document was developed and plans for a prototype program were completed. In FY 1998 a real-time interface for HEC-RAS for the WCDS was completed and integrated into the software system.

During the thire quarter of FY 1999 the interface update was completed to meet Version 2.2 capability. The software was included in the WCDS deployment to Baltimore, Huntington, and Omaha Districts, plus the North Pacific Division. Development of the unsteady-flow modeling for the WCDS will commence in the fourth quarter.

Flood Impact Analysis

(planning 3rd/99 W99-058)

The Flood Impact Analysis (HEC-FIA) computer

program development continues with debugging and testing performed during the quarter. Modifications for UNIX operations and integration with the Control and Visualization Interface (CAVI) for the WCDS were nearing completion at the end of the third quarter. The procedures for incorporating the project benefit accomplishments component of the program was agreed to by the field review group and HQUSACE. HEC is also working with the RS/GIS Center at CECRL on their implementation of the GIS flood impact analysis capabilities for water control applications. The program is being designed and tested under the general direction of the water control flood impact analysis design team consisting of Corps field offices, CECRL, and HEC representatives. The Beta version is being applied at the Baltimore, Huntington, Omaha, and Portland districts WCDS deployment sites. The goal is to have the HEC-FIA Version 1.0 program ready for release and fully integrated with the WCDS system by early in the first quarter of FY 2000.

System Integration, Implementation, and Management

(tech asst 3rd/99 AFP W99-059)

The activities of the third quarter of FY 1999 were impacted by the test deployment of the WCDS software at the four test field sites. Several activities related to the administration of the WCDS modernized project continued during the third quarter of FY1999. Quarterly progress charts have continued to be used to monitor the progress of the development and deployment of Version 1.0 of the new WCDS software. The charts help focus attention on different aspects of the project, allowing resources to be moved or allocated in order to keep the project on track with proposed budgets and schedules.

Another activity which continued during the third quarter has been the continued use of weekly pre-deployment conference calls to coordinate activities at the various deployment sites and the WCDS developers. The phone conferences are typically held on Wednesday mornings each week and focus on reports from each of the developer team members and each of the deployment sites. This forum has been particularly useful in allowing discussions about different aspects of the WCDS software and to disseminate information about up-coming deployment activities. These calls continue throughout the deployment activity.

Procedures were put in place that allow multiple versions of the complete set of WCDS software to reside and execute on the same machine without interference. This is critical to the testing of changes without interfering with production software. The procedures currently permit any number of software versions and any number of data areas to be defined. A given user then may select the software version and data area to be used by setting appropriate system environment variables.

Refinements to the WCDS software structure have also continued. In addition to alterations to the WCDS directory structure, properties files containing WCDS system variables have been implemented. The properties files are used by each of the software components to establish items like network addresses, port numbers, number of process threads, etc. When fully implemented the properties files will exist in the same directory and specify all of the WCDS system parameters.

Application of GIS and Image Technology

(research 3rd/99 W99-060)

GIS programs for calculation of inundated areas during forecasting have been integrated with the WCDS modeling suite and the CAVI. CorpsView data environments and controls have been reconciled with the CAVI and the WCDS file system. Inundation mapping programs are being installed at the test sites. CorpsView installations will be preformed separately.

Control and Visualization Interface

(tech asst 3rd/99 WJC W99-061)

Most of the effort this quarter focused on the implementation and testing of the CAVI software on the four field test sites. The client side was run on a PC running MS Windows NT (4.0) and the server was run on the Sun Sparc. Modifications that were made for deployment to the field include changes to the forecast run alternative naming conventions, and specifying parameters (HEC-DSS “C” parts) for individual nodes when generating plots and tabulations.

Deployment support was provided on Version

1.0 of the CAVI at the four deployment offices. The work has been primarily "clean up type," with changes made for situations that were discovered in field deployment, and suggestions of the deployment testers.

Field Application Assistance

(tech asst 3rd/99 CWF W99-062)

During the third quarter of FY 1999, deployment of the Water Control Data System (WCDS) was completed at four sites in the Corps of Engineers. The deployment sites were Baltimore District, Huntington District, Omaha District and the Division office in Portland, Oregon. Field Application Assistance activities for this period of time consisted primarily of providing help to each of the four WCDS deployment sites. After the official deployment period was over, many problems which were discovered during the fielding of the software were addressed. A major portion of the effort was divided providing support to the Data Acquisition and the Modeling components of the WCDS software.

On the Data Acquisition side, most of the assistance was given in use of the software and help in debugging the loading of data into the Oracle Database. Also considerable time was spent on reducing inefficiencies of the data capture and loading process. On the modeling side, assistance was also provided to each of the four deployment sites. Here most of the effort was spent in finding errors which were generated during the modeling process. As errors were found and corrected, a new set of "jar" were produced and distributed to the field for testing. In addition to the Data Acquisition and Modeling components, Field Application Assistance was also provided to administer the Oracle database. Issues as loading historical data, data archiving, starting and stopping Oracle, defining data parameters and locations were addressed during phone calls in the post-deployment period.

NUMERICAL MODEL MAINTENANCE AND SUPPORT

Numerical Model Maintenance for the family of HEC software consists of bug fixes and minor updates, hardware/software platform support, documentation updates and hot-line technical support. Corps offices that subscribe for these fee services will receive full support including: new software releases; interim updates and bug fixes; user's manuals and supporting documentation; short-duration technical consulting; and hot-line technical assistance via E-mail, fax, and telephone. Corps offices that do not subscribe are limited to the same courtesy afforded to other federal agencies: referral to HEC Web page and the National Technical Information Service (NTIS) for major software release versions; HEC Web page and NTIS for documents; and response to official correspondence regarding potential program errors and bugs. Subscription fees for FY 1999 total just over $500,000. Subscription fees continue to arrive - still short a few at this 3/4 year point. The primary software within each numerical model area together with the number of requests for assistance over the previous one year period, are shown below. A discussion of significant activities in each of the modeling areas follows the table. (executive 3rd/99)

Numerical Model Area	Primary Software	Latest four quarters Calls for assistance				
		4th Quarter FY 98	1st Quarter FY 99	2nd Quarter FY 99	3rd Quarter FY99	Totals
Hydrologic Analysis	HEC-1, HMR52, HEC-HMS	37	74	61	55	227
River Analysis Systems	HEC-RAS, HEC-2, UNET, HEC-6	52	33	38	43	166
Flood Damage Analysis	FDA	63	41	47	33	184
Hydrologic Statistics	HEC-FFA, STATS	12	2	17	6	37
Reservoir System Analysis	HEC-5, HEC-5Q, HEC-PRM	17	10	4	10	41
Data Storage System	HEC-DSS	32	4	23	45	104
Interior Flood Hydrology	HEC-IFH	11	7	5	3	26
TOTALS		224	171	195	195	785

Hydrologic Analysis (HEC-1, HMR52, HEC-HMS)

(research 3rd/99 M99-001)

Maintenance this quarter continued to concentrate on user support and bug fixes for HMS; Version 1.1 was completed and released. Software for tracking program problems, suggestions, and bug fixes is proving to be very helpful. An internal test of the HEC-HMS support Web-site was implemented to provide users up-to-date information on program problems and development activities. The Web-site will be made public next quarter. Other support was provided for HEC-1, HMR52, urban H&H models; and the groundwater model MODFLOW.

Flood Frequency Analysis (HEC-FFA, STATS)

(research 3rd/99 M99-004)

Program support was provided to district offices for program FFA, STATS and REGFRQ. Some further follow-ups to the UNIX version of FFA and REGFRQ were also made.

Interior Flood Hydrology (HEC-IFH)

(research 3rd/99 M99-007)

Version 2.0 of the computer program, "Interior Flood Hydrology" (HEC-IFH) was released for general use in January. Version 2.0 of the program includes some enhancements, numerous error corrections, and a revised user's manual. The main program changes

include: (1) ability to run under the Windows NT; (2) pump analysis results are now saved with the plan results; (3) input file date stamps are checked to preserve consistency between input and analysis results; (4) pond routing calculations have been refined; and (5) increased precision has been added. Technical support and assistance for the HEC-IFH program will continue, but no additional modifications will be made to the program. It is planned that interior area analysis capabilities will become part of a future version of the Hydrologic Modeling System (HEC-HMS) program.

***Flood Damage Analysis** (HEC-FDA)*
(planning 3rd/99 M99-003)

Consultations with Corps offices using risk-based analysis methods remain at a high rate. Enhancements and corrections to the HEC-FDA program and its database processing procedures were made during the quarter. Work on fixing minor bugs in the program for the Version 1.1 program release continued during the quarter.

***River Analysis Systems** (HEC-RAS, HEC-2, UNET, HEC-6)*
(training 3rd/99 M99-002)

Application assistance and one-stop phone assistance continues for HEC-2, HEC-6, UNET, and HEC-RAS. Version 2.2 of HEC-RAS was distributed with new program documentation. A Version 2.2.1 patch was released during the third quarter to correct two compute problems. HEC-RAS and UNET have continued to be the focus of model assistance.

***Reservoir System Analysis** (HEC-5, HEC, 5Q-HEC-PRM)*
(training 3rd/99 M99-005)

General maintenance and field support activities for the HEC-5 family of programs continue. Program updates and modifications for complex system operation goals continued. Program assistance continues on a request basis.

***Data Storage System** (HEC-DSS)*
(tech asst 3rd/99 AEM M99-006)

Support and Data Management activities for the third quarter were primarily centered around providing telephone support and routine maintenance for the various data management tools. Most of the support centered around the primary HEC-DSS management tools, such as SHFDSS, DSSSHF, DWINDO, DSSUTL, DSPLAY , REPGEN, and DSSMATH. Work was completed on making SHFDSS 'Y2K' compliant and was provided to several Corps offices for testing. The 'Y2K' compliant SHFDSS has been renamed SHEFDSS and will be available for Corps wide distribution by the end of the fourth quarter.

Technical Assistance and Special Projects

Technical Assistance Projects are reimbursable projects performed for HQUSACE, Corps district and division offices, research laboratories, other federal agencies, and local governments. The scope of each project is negotiated on a case-by-case basis, including the full range from technical advisory services, review and oversight of studies by others, to performance of all aspects of investigations. Arrangements are made such that contracting associated with technical assistance projects is credited to the sponsoring office's contracting-out percentage. New projects begun this quarter include: HEC-5 hydropower model and analysis for Cumberland River system (NWD); groundwater modeling for Tooele base contaminant analysis (SPK); evaluation of the relationship of the WCDS system to ERDC's proposed LMS, Land Management System (ERDC/CHL); HEC-FIA (flood impact) model for Iowa and Des Moines rivers (MVR); rule-based reservoir model development for MVR WCDS implementation (MVR); and GIS data base, HEC-GeoRAS applications for Tres Rios project studies (SPL). (executive 3rd/99)

HQUSACE

CECW-EH

Mississippi Basin Model System Model Update **$960,000**
(executive 3rd/99 P99-004)

HEC is managing the project that is updating the model geometry for the Mississippi Basin Model System (MBMS) for the upper Mississippi to reflect more recent mapping and to develop an inundation mapping component based on the new mapping. The project continues in full production. The project will merge the several mapping sources into a digital terrain model (DTM), cut spatially located cross sections from the DTM, and integrate the new data into re-calibrated UNET models. Automated inundation area mapping based on UNET forecasts will be made operational for selected areas. Contracts to merge the data sources and cut the cross sections have been awarded. Location of cross sections, electronic bathymetry, and integration of the new geometry into the existing models is being accomplished by the St. Louis, Rock Island, St. Paul, Kansas City and Omaha Districts. Mapping contracts for DTM development and geometry extraction are being managed by the St. Louis District. New digital cross section data will start flowing to the districts in the fourth quarter and be completed in the second quarter of FY 2000. A workshop was held that focused on tools and techniques for integration of the new digital geometry into the existing UNET models, and techniques for re-calibration of the models. The MBMS update is expected to be completed in FY 2000.

Residual Flood Risk **$ 50,000**
(planning 3rd/99 P98-021)

HEC is developing procedures and capabilities to define and better communicate the residual flood risk associated with project conditions. This includes addressing residual risk for various flood conditions, project types (levees, channels, detention storage, nonstructural measures) and physical settings (population at risk, egress, damage potential) consistent with requirements of ER 1105-2-100, ER 1105-2-101, and EM 1110-2-1619. Within this framework, the analytical procedures and capabilities to better depict and communicate residual risk for formulating and evaluating flood damage reduction plans will be derived. Included are methods using risk and uncertainty to develop project performance and site information. The methods will ultimately be incorporated into the HEC-FDA computer program and distributed to Corps offices via brochures, videos, and CD's. Research work was limited during the third quarter.

Hydrology Committee **$22,500**
(research/3rd 99 P99-009)

HEC is assisting Headquarters Hydrologic Engineering Branch with conducting this year's Corps Hydrology Committee meeting. An agenda and facilities for a meeting at The Dalles, Oregon were completed. Most of these funds are for committee members travel.

GAGE Computer Upgrade **$19,883**
((tech asst 3rd/99 P98-093)

The gage Oracle/Web application software was successfully used in the previous Corps-wide data update cycle. Work is now deferred pending compilation of comments and improvement needs resulting from field experience. A prioritized list of improvements will be worked on, beginning in the fourth quarter.

CECW-PF

FPMS Support **$30,000**
(training 3rd/99 P99-005)

HEC is preparing a technical paper on the application of new GIS procedures to develop input to HEC-RAS and to display output as floodplain mapping. The paper was presented at the annual Association of State Floodplain Managers Conference in Portland, Oregon, at the end of May.

Engineer Research & Development Centers

Construction Engineering Research Laboratory

LMS to WCDS **$40,000**
(research 3rd/99 P99-017)

Assistance was provided in the application of the Corps life cycle management information system, LCMIS, to the Land Management System, LMS, being developed at Corps Labs. HEC is providing guidance based on its experience with the LCMIS developments for the Corps Water Control Data System, WCDS.

Coastal Hydraulic Lab

LMS Development Team **$20,000**
(research 3rd/99 P99-012)

HEC is participating in the development of the Corps new Land Management System, LMS. Several documents have been reviewed and meetings attended.

Great Lakes and Ohio River Division

Pittsburgh District

Coal Mining Hydrologic Impacts **$16,000**
(research 3rd/99 P99-001)

Assistance continues to be provided for hydrologic analysis of impacts of coal-mine-land restoration. Reviews of appropriate modeling techniques and District plans were provided.

Mississippi Valley Division

Rock Island District

Upper Mississippi River System Flood Frequency **$100,000**
(research 3rd/99 P99-003)

A report recommending methods for the flood frequency analysis was reviewed by the Technical Advisory Group and presented to the task force meeting in April. The previous analyses of annual peak unimpaired flow frequency curves were updated and expanded. Also, HEC presented an overview of flood frequency analysis to the Citizens' Advisory Group and answered their questions about the study. After the task force meeting, HEC organized and conducted a Corps technical coordination meeting; several problem areas were discussed and solved. Much discussion and coordination between FEMA and the Corps regarding floodplain mapping was participated in by HEC.

Reservoir Modeling **$50,000**
(training 3rd/99 P99-019)

Rock Island District has requested development of rule-based reservoir simulation as a component of the water control data system (WCDS). During the third quarter, HEC conducted a test and developed a progress report on the concept of using multiple-linear programming to "solve" the release decision based on reservoir-release rules. During the fourth quarter, HEC will develop an implementation plan to incorporate the technique in the RSS program.

HEC-FIA Modeling **$30,000**
(planning 3rd/99 P99-018)

HEC agreed to assist the Rock Island District with development of a HEC-FIA model for the Iowa and Des Moines River basins and extending it downstream on the Mississippi River to Quincy, Illinois. Work on the data entry will be initiated early in the fourth quarter.

Northwestern Division

HEC-5 on the Cumberland **$24,000**
(training 3rd/99 P99-014/015)

HEC is developing an HEC-5 model for hydropower evaluation. During the third quarter, flow data were processed and an initial HEC-5 data model was developed. Detailed hydropower data is expected from unit testing.

South Atlantic Division

Charleston District

HEC-5 Model **$14,000**
(training 3rd/99 P99-007)

HEC is providing assistance to the Charleston District developing an HEC-5 reservoir model for the Pee Dee River. During the first quarter, data assembly began and a framework HEC-5 data set was developed. During the second quarter, the HEC-5 model was completed. A tech-transfer meeting was held in April.

Mobile District

Panama Canal Base Model **$149,420**
(training 3rd/99 P98-073)

HEC is assisting the Panama Canal Commission (PCC) with an analysis of surface water availability for canal expansion. During FY 1998, HEC developed flow data for modeling and developed an HEC-5 and preliminary HEC-PRM reservoir system models for the existing system. During the first quarter of FY 1999, HEC presented an HEC-DSS workshop on the DSS programs used for data processing and an HEC-5 modeling workshop to the PCC staff. Reservoir model development for existing conditions was completed during the second quarter and an HEC-PRM workshop was presented to PCC staff during March. The draft flow-data report was completed and sent during the third quarter.

Choctawhatchee-Pea River **$10,000**
(research 3rd/99 P98-082)

Training of District and local staff was provided as planned. Additional work on the Choctawhatchee-Pea River flood forecasting system improved the flow forecasting and river hydraulics models for the lower part of the basin.

South Pacific Division

Los Angeles District

Santa Ana River **$65,750**
(training 3rd/99 P99-008)

HEC is developing an HEC-RAS model of the upper Santa Ana River. This will be a demonstration project using GIS data, and the new procedures, developed under the GIS work unit, to develop model data and to present model results. A tech-transfer workshop is planned to present the procedures used and the study report will likely be published as an HEC Project Report. The project just started during the first quarter of FY 1999 and basic data are still being assembled. During the second quarter, a field review of the project was conducted and study plans were developed. During the third quarter, HEC-RAS modeling was nearly complete and sediment modeling was initiated. Mapping and report preparations will be initiated during the fourth quarter.

LAPRE-1 Capabilities for HEC-HMS **$19,000**
(research 3rd/99 P98-094)

Methods for incorporating dimensionless unit graph and design storm capabilities have been reviewed and tasks are scheduled to include this capability in HEC-HMS Version 2.1. Some specialized hydrologic capabilities and historical storms unique to the District will be provided via HEC-DSS and/or stand-alone support software.

Tres Rios GIS Database **$30,000**
(planning 3rd/99 P99-020)

HEC is providing technical assistance to the Los Angeles District's Phoenix office on its Tres Rios constructed wetlands feasibility study. HEC's help is primarily for GIS applications and displays involving alternative plans impacts on flood damage to residential and commercial structures and GIS depictions of depth and velocity distribution patterns throughout the study area. The work was initiated during the third quarter and applied HEC-GeoRAS to generate

the flood inundation and depth of flooding displays. The Tres Rios assistance will continue through the fourth quarter.

Sacramento District

Phase I Sacramento and San Joaquin River Basins Comprehensive Study **$385,000**
(planning 3rd/99 P98-049)

HEC assisted the Sacramento District in its Phase I Sacramento and San Joaquin River Basins Comprehensive Study by developing Phase I level flood damage and reservoir system models of the two basins. The Phase I effort evaluated the 1995 and 1997 flood events. Separate HEC-5, HEC-FCLP, and HEC-FIA models were developed for the Sacramento and San Joaquin reservoir systems. The project was during the third quarter and produced the following products.

Reservoir System Modeling. Two types of reservoir system analyses were performed: simulation modeling using the HEC-5 computer program; and optimization analysis of water allocation of the systems using the HEC Flood Control Linear Program (HEC-FCLP). The Phase I objective was to develop functional system models for the Sacramento and San Joaquin systems for the 1995 and 1997 floods. A report, Flood Control Optimization Analysis Using HEC-FCLP for the Phase I Sacramento and San Joaquin River Basin Study, was prepared and undergoing internal review at the end of the quarter.

Flood Impact Analysis. HEC-Flood Impact Analysis (HEC-FIA) models for the Sacramento and San Joaquin basins were completed during the quarter. The Phase I models were calibrated to the 1995 and 1997 observed event data. Information on the 87 impact area stage-urban damage, stage-number of structures, and stage-population functions, as well as, crop distribution patterns were provided by the Sacramento district and included in the models. The HEC-FIA model will enable planning and real-time event assessments of flood impact of the Sacramento and San Joaquin systems. A report, Development of HEC-FIA Models for the Phase I Sacramento and San Joaquin Rivers Basin Study, was finalized and published during the third quarter.

Tooele Army Depot Groundwater **$50,000**
(research 3rd/99 P99-006/016)

New pumping data is being collected and the Tooele groundwater model is being recalibrated. Briefings were provided to the District and the Utah team. The annual report was update for Utah EPA.

Other Agencies

Metropolitan Water District of Southern California

Upgrade of HEC-DSS **$48,000**
(tech asst 3rd/99 WJC P97-105)

Work on this activity for the third quarter FY 1999 is awaiting related graphic and data base development from WCDS tasks. Prior quarter remarks follow.

The Metropolitan Water District of Southern California, the California Department of Water Resources, and HEC are combining resources to develop a new Graphical User Interface (GUI) for the HEC-DSS package. This tool will provide greater graphing and data manipulation capability of data in a HEC-DSS data base. The tool is being developed in the

Java programming language, and will run under most operating systems including UNIX, Windows 95 and Windows NT.

A “map-based” interface has been developed which can act in a client-server mode, if desired. The map GUI is being developed in conjunction with the Water Control Modernization “CAVI” Project (so we have additional resources to work on the same software). The GUI reads in a map configuration file that can be produced from several sources, such as a GIS. The map has several tool items, like zoom, pan, etc. A user will select the data parameter and version from a box on the right side of the map, then select a location to either plot, tabulate, etc., the data.

This project is closely coordinated with the WCDS modernization project. Work will be re-initiated subsequent to completion of deployment of Version 1.0 and associated validation efforts.

National Institute of Building Sciences

Potential Flood Loss for HAZUS **$30,080**
(executive 3rd/99 P98-071)

The Federal Emergency Management Agency, FEMA, is sponsoring the development of a flood loss module addition to the HAZUS model. HAZUS is a multi-hazard modeling and analysis software system currently operational for earthquakes. Additions now underway include wind and flood hazards. FEMA has engaged NIBS to manage the project. In turn, NIBS has contracted for model development with private firms. Model development is guided by multi-agency, university, private sector oversight committees formed for each hazard component. The HEC Director is contracted to serve as a committee member for the flood module. Activities to date this FY include participation in committee meetings that addressed: phase I model development proposals and proof-of-concept applications; contract proposals for phase II work; and evaluation of proposed default national data base attributes.

TECHNOLOGY TRANSFER

Two PROSPECT courses were presented during the third quarter, as shown in Table 1. GIS for Hydrologic Engineering provides the basic skills to utilize a Geographic Information System (GIS) to develop data and display results for hydrologic and hydraulic engineering analysis. This course provides information in lectures and workshops on: (a) GIS concepts and their application in H&H analysis; (b) acquisition of GIS data sets; (c) the National Geospatial Data Clearinghouse, and Corps of Engineers policies on geospatial data and systems; (d) use of GIS data sets and Arc/Info with the HEC-HMS for hydrologic analysis and HEC-RAS for river hydraulics; (e) combining H&H results with GIS data sets for flood analysis and planning; and (f) case studies of GIS application in H&H analysis, feasibility studies, and water control.

The Hydrologic Modeling System (HEC-HMS) class provides knowledge and experience in simulating rainfall-runoff processes using HEC-HMS as a tool. Applications include floodplain management and water resource planning studies. The course covers basic hydrologic engineering techniques for rainfall-runoff analysis, with emphasis on: rainfall-data processing; loss rate (infiltration) methods; unit hydrograph and kinematic wave methods for modeling runoff throughout a watershed composed of multiple subbasins and river reaches. Workshops will provide hands-on experience in applying HEC-HMS, the “next-generation” successor to the Corps HEC-1 Flood Hydrograph Package. HEC-HMS operates through a GUI to create models, perform simulations, and review results. The program contains capabilities of HEC-1, plus new capabilities for spatially distributed runoff and continuous simulation. The program operates on MS and X-windows systems.

Other Training Activities

Two workshops were presented during the third quarter, as shown in Table 2. HEC provided an HEC-RAS workshop to State and Federal engineers in Michigan. Also, HEC provided an HEC-HMS workshop to State and Federal engineers in Indiana. Both workshops were sponsored by the Detroit District Floodplain Management.

Table 1. HEC FY 1999 PROSPECT TRAINING SCHEDULE

Course Title	Date	Length (weeks)	Number Students
Basic HEC-RAS	26 - 30 Oct 1998	1	24
Risk-based Analysis	16 - 20 Nov 1998	1	15
GIS - Hydrologic Engr	12 - 16 Apr 1999	1	26
Basic HEC-HMS	17 - 21 May 1999	1	31
Water and Watershed	12 - 16 Jul 1999	1	
Groundwater Hydrology	16 - 20 Aug 1999	1	
	TOTALS:	6	96

Table 2. HEC FY 1999 WORKSHOPS

Title	Sponsor	Date	Length (days)	No. of Students
HEC-DSS Workshop	Panama Canal	17 - 20 Nov 1998	4.0	7
HEC-HMS Workshop	FEMA	30 Nov - 4 Dec 1998	4.5	30
HEC-5 Workshop	Panama Canal	1 - 4 Dec 1998	4.0	8
HEC-HMS Workshop	CENWO	12 - 15 Jan 1999	3.5	24
Flood Damage Analysis	CECW-PM	9 - 11 Mar 1999	3.0	15
HEC-PRM Workshop	Panama Canal	17 - 19 March 1999	3.0	5
HEC-RAS (E.Lansing, MI)	CELRE	11 - 14 May 1999	3.5	27
HEC-HMS (Indianapolis, IA)	CELRE	22 - 25 June 1999	3.5	
		TOTALS:	25.5	116